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*"To the solid ground
Of Nature trusts the mind which builds for aye."*—WORDSWORTH.

THURSDAY, NOVEMBER 3, 1898.

ANALYTICAL CHEMISTRY.

A Manual of Chemical Analysis, Qualitative and Quantitative. By G. S. Newth. Pp. 462. (London: Longmans, Green, and Co., 1898.)

A Laboratory Guide in Qualitative Chemical Analysis. By H. L. Wells, M.A. Pp. 180. (New York: Wiley and Sons. London: Chapman and Hall, Ltd., 1898.)

A Short Course in Inorganic Qualitative Analysis. By J. S. C. Wells, Ph.D. (New York: Wiley and Sons. London: Chapman and Hall, Ltd., 1898.)

IT is now becoming generally recognised that chemical analysis is a subject that may be looked at, taught, and practised in two ways—as an art, or as a science. No doubt it should be both, and always has been both with chemists properly so-called; but it is sad to think of the time, trouble and money that have been expended during the last thirty years in disseminating a smattering of the analytical art on the supposition that education and even British industry would be thereby furthered.

The demand for a practical chemistry that could be easily scheduled, that should not be too elaborate, and that could be examined and controlled by sending out packets of powders and getting back packets of papers, has contributed, doubtless, more than anything else to the degradation of chemical analysis. At the same time it must be admitted that chemical analysis as a science suffered seriously by the abolition of the ideas and notation of the dualistic theory. Before then the current names and formulae were at least consistent, and the writing of equations could be conducted on comparatively simple general principles. Even now there are probably few chemists who would calculate the oxidising value of potassium permanganate in reference to ferrous sulphate, otherwise than by dualistic conceptions and formulae. The hopeless confusion arising over the old terms *acid*, *base* and *salt*, and especially *basic salt*, in their modern use, must be known to every teacher.

To those who in recent years have protested against chemical analysis as an introduction to practical science

it has been objected that analysis, when properly taught, is a highly educative subject. But this has never been disputed; the point is that analysis is far too high a science and too difficult an art for young boys, and that a little proficiency in the art of "taking a solution through the chart" has, practically speaking, been the only attainable outcome of a positive kind, whilst the habits of mind and manipulation usually engendered have been lamentable.

The tide is happily with the reformers, and the improvement that has taken place within the last ten years in school science is one of the most remarkable and gratifying of the numerous signs now evident that a more rational and humane spirit is pervading British education.

For those who wish to make a serious study of chemistry, chemical analysis has still to be taught, and how to teach it best, is a question which may perplex the most thoughtful teacher. The fundamental difficulty is that there appears to be no thin end to the wedge. If the subject is to be taught scientifically—that is to say, if the reactions on which analysis is based are to be elucidated as they arise—the student is at once thrust into a thicket of ramifying facts in which he will find his way with difficulty. Suppose he begin with the reactions of the silver group, he is at once among the mercuramines; should he begin at the other end, there are the platinichlorides and acid tartrates. The student, in fact, who is to learn analysis scientifically at the first attempt, requires a fair knowledge of chemistry to begin with. The choice lies between devising some extended practical work, beyond the mere preparation of gases, as a preliminary to analysis, or making the student, as he might put it, "do analysis" more than once. In the last case, the analytical operations are not comprehended to their inmost parts in first traversing the course, but a preliminary survey is obtained, and the student learns something, at least, about a great many substances and reactions. It is, after all, something to know the mere outside of things in chemistry. The difficulty, however, is to secure the *da capo* or cud-chewing process which is essential to the success of this scheme. It is not easy to convince the half-informed of

their ignorance. No doubt, the best way to approach analysis is through preliminary practical work in which typical substances are prepared by typical reactions, and subjected to a careful qualitative and quantitative study; but no one has yet given a really good lead in this direction, though several books of inorganic preparations have appeared in recent years.

Sooner or later the serious student of chemistry must enter upon the systematic study of analysis, and the selection of a good handbook becomes an important matter. It has been the habit for writers on analysis to confine themselves almost entirely to the technique of the subject, and among the scores of books written a fair number might be named as trustworthy guides in the processes of qualitative and quantitative analysis. At the head of these stands the well-known work of Fresenius—a monument of industry and care. It must be recognised, however, that Fresenius' book is essentially an analytical dictionary. If it be an object in the teaching of analysis—and it is surely, for the general student, the chief object—to make the learner familiar with the philosophy of the subject, the use of Fresenius and the smaller versions of Fresenius must be supplemented by something else, either in the way of oral teaching or literature. The circumstances of few laboratories permit of the constant personal supervision which is necessary to keep an analytical student straight on the theoretical side of his work, and thus the possession of a book which really grapples with the chemistry of analytical reactions becomes indispensable. It is, however, only recently that a book adequately fulfilling this purpose has appeared in the English language, though a little-known manual published by the late Prof. Dittmar, in 1876, deserves respectful mention. In Germany (and doubtless in Russia) for many years Menshutkin's book has occupied the place in question. Menshutkin does not pretend to be an exhaustive compendium of analytical processes; it contains no tables; it lays down no laws for the treatment of a solution containing a limited number of acids or bases; yet Menshutkin has the stamp of individuality and real science, which make it not unworthy of companionship with Mendelejeff's Principles. It was the only book on analysis which Bunsen, who had a horror of the analytical "Bradshaw," would allow to appear in his laboratory. It is to be hoped that through its English translation the book has become better known in this country.

One more type of work on analysis, and only one, can be mentioned. Ostwald's "Scientific Foundations of Analytical Chemistry" is a book *sui generis*. The view taken of this book will depend entirely on whether the reader finds the preamble proven. If the ionic theory of solution be accepted, there can be no doubt of the remarkable coherence and symmetry of Prof. Ostwald's adaptation of it to the facts and processes of analysis. The book is well worth the attention of any one who may have lightly taken up a mere prejudice against the ionic theory.

Of the books at present before us, two are of considerable interest as being out of the common style. Mr. Newth, who is well known as the author of a book of lecture experiments, and one on inorganic chemistry, both

characterised by many excellent features, has now produced a manual of analysis which is no less satisfactory. It is written much in the style of Menshutkin, that is to say, it is thoroughly explanatory. At the same time there is no lack of plain practical directions for the conduct of analytical work. The book gives evidence throughout of having been written by a skilled analyst and a thoughtful chemist, whilst the frequent asides—sometimes beseeching, sometimes scornful—show that the author has tasted the sorrows of a teacher of analysis. Beginning with a chapter of preliminary manipulative exercises, the book proceeds to detail and explain the reactions of the metals in the order of the analytical groups. Two chapters follow on the conduct of a qualitative analysis and the statement of results. The second part of the book deals with quantitative analysis, including electrolytic analysis, gas analysis and organic analysis, concluding with a section on miscellaneous physico-chemical determinations. This brief summary of contents will, of course, give little idea of the real character of the book, yet it is impossible to enter minutely into either explanation or criticism of a work so full of details. The least satisfactory part is the first chapter dealing with the important matter of manipulation. In the first place it must be remarked that the essentials of manipulation should have been learned long before the systematic study of analysis is commenced, and a student who is at all ready to enter upon the second chapter of Mr. Newth's book will very probably resent the instruction to mix hydrochloric acid and charcoal in order to see how the charcoal may be filtered off and washed. Such elementary instructions are doubtless useful in their place; but their juxtaposition with chapters on systematic analysis only tends to confirm the practice of plunging students of practical chemistry prematurely into analytical work. It would at least have been better if this intention had been disclaimed. The instructions themselves also call for some comment. No recommendation is made of the filter-pump for qualitative analysis, an omission which, in the opinion of the present writer, is very regrettable. It is true that in the hands of a careless and uncontrolled student a vigorous filter-pump is a source of moral degradation, but, in other hands, it is, with limited exhaustion, perhaps the chief aid to dispatch, neatness, and even accuracy. The instructions given by Mr. Newth for evaporation, neutralisation, the use of borax beads, and the removal of precipitates seem to show that many of Bunsen's helpful artifices are still unknown in England. Other useful things which do not seem to be described by Mr. Newth, are the Gooch crucible and the perforated disc porcelain funnel. The writer would also here recommend the process of separating barium, strontium and calcium by means of nitric acid, described by Dr. S. G. Rawson in the number of the *Journal of the Society of Chemical Industry* for last February.

An addition that may well be made to a future edition is a plain statement about the rational use of figures in quantitative analysis. It is astonishing how little attention is paid by chemists to the significance of figures in the statement of an analytical result, and how seldom students are taught to let their recorded numbers bear a

proper relation to the accuracy attainable, even with perfect manipulation, in any given process. It is the commonest thing to find a pretension to accuracy of 1 part in 1000 where 1 in 50 would hardly be justified.

Mr. Newth does not introduce the ionic theory into his explanations of analytical reactions. It is not difficult to understand reluctance to embrace a theory which is still young and still the object of adverse criticism. At the same time it seems a great pity that a writer on analysis should leave the student in ignorance of what, according to a large number of eminent chemists, is the real key to the chemistry of analysis. The ionic theory need not have been woven into the fabric of the book; but it, at least, deserved a chapter and a fair hearing.

Whilst a few defects are to be noticed in the book, it is right to add that the merits are much more conspicuous; and it may be said, on the whole, that Mr. Newth's account of analysis is wide in scope, exact in detail, and particularly luminous in exposition. If it is used conscientiously by duly prepared students, it will teach them a great deal of chemistry.

Prof. Wells's book is written on somewhat different lines, yet is characterised, like Mr. Newth's, by the attention paid to the explanation rather than the mere description of reactions. Prof. Wells, who has charge of the teaching of analytical chemistry and metallurgy in the Sheffield Scientific School of the Yale University, is evidently deeply impressed with the feeling that students tend to do their analytical work in a mechanical way, taking merely marching orders from their text-books. Instead, therefore, of telling the student anything about the metallic chlorides, the author contrives that the facts shall be *discovered* by such instructions as:

"Find by experiment which of the twenty-seven solutions give precipitates when a few drops of hydrochloric acid, HCl, are added to 1 or 2 cc. in a test-tube. Write the equations of the reactions and remember the facts observed in this experiment as well as in those that follow. Why are no precipitates produced in the solutions containing chlorides?"

The directions continue in the same strain. It must be observed that the student does not proceed on a natural voyage of discovery. At every port he opens another sealed order, and takes the directed course wherever it may lead. The value of this method of teaching analysis is open to serious doubt. The student is asked to perform twenty-seven experiments, of which all but three are, practically speaking, blanks. The present writer's experience is that operations of this kind pall intolerably upon a self-respecting student. We surely have here a case where a wrong sacrifice is made to pedagogic theory. In the early stages of education it is no doubt hardly possible to pay too much attention to method. Whilst habits of mind are being formed, and pupils are young and docile, much may be permitted in the name of method; but a period arrives when the leading strings must be relaxed. As soon as a system of teaching is felt by the pupil to be a system, it is apt to lose its value, and to engender the resentment which every one feels on discovering that he is being manoeuvred. The present writer has had experience of the unintelligent student of practical chemistry, and has tried Prof. Wells's device,

among others. The result has not been at all encouraging. The fact is, that by the time a student is fit to begin the study of analytical chemistry he should be fit to avail himself of straightforward explanations. If he is not fit, strategy will do but little to mend matters. Prof. Wells, however, thinks differently after fourteen years' teaching and it may be that things are different in America.

Whilst offering this general criticism of Prof. Wells's system, it is right to add that the book is wholly good in its scientific tendency, and that it contains abundant evidence of the writer's experience and grasp of analytical chemistry. The injunction that the student is to construct his own tables of separations is much to be commended. The second part of the book deals with theory; it embraces the ionic theory, and explains the phenomena of analysis from that point of view. The explanations are, it is to be feared, too brief and sketchy to be of much use. They have a somewhat high-sounding logical form, but do not always convey much substance.

"There is a direct connection between the formation of precipitates and insolubility. A compound which is readily soluble in the liquid that is present *cannot* form a precipitate in the presence of a sufficient amount of that liquid."

This surely was unnecessary.

The chapter on equations is clear and useful. The third part of the book gives an account of the properties of the inorganic radicals in alphabetical order, and does not purport to be more than a condensation of Fresenius. It contains a summarised statement of what the student is meant to have learned for himself by working through Part i.

Two "appendixes" to the book, consisting of eighteen pages of labels, seem very unnecessary.

The third book before us is also of American origin. It is intended for engineering students, though there is no evidence of this special destination in the text. In so far as the reactions are explained with fair completeness, it is in advance of the customary analysis book. The distinctive feature is to be found in a number of large tables plotting an outline of reactions which occur in the separation of the members of a group. By reference to the tables it is possible to see what is the maximum number of substances in any particular precipitate or filtrate. Thus precipitate 35 may contain BaCO_3 , SrCO_3 , CaCO_3 , whilst filtrate 35 may contain MgCl_2 , NH_4Cl , NaCl , KCl , BaCl_2 and CaCl_2 in traces, NH_4OH , $(\text{NH}_4)_2\text{CO}_3$. The author states that these tables have been found of much benefit to the student.

In the beginning of the book we find the statement that "in inorganic chemistry the bases comprise the metals, and the acids the non-metallic elements (with a few exceptions)"; a little later—"all acids contain hydrogen, which hydrogen is replaceable by a base"; and lastly—"bases have properties just the reverse of acids. Among the inorganic compounds they usually consist of hydroxyl in combination with a metal. Their chief characteristic is their power of uniting with acids to form neutral compounds." Could any better justification be found for the remark, made early in this article in reference to the dire effects of lingering dualistic terminology?

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